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ABSTRACT

This instructional guide, intended for student use, develops the subject of technical research through a series of sequential activities. A technical development of the subject is pursued with examples stressing practical aspects of the concepts. Included in the minicourse are: (1) the rationale, (2) terminal behavioral objectives, (3) enabling behavioral objectives, (4) activities, (5) resource packages, and (6) evaluation materials. Student activities deal with each of the major steps in the research process. This unit is one of twelve intended for use in the second year of a two year vocationally oriented physics program. (CP)

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CAREER ORIENTED PRE-TECHNICAL PHYSICS

Technical Research

Minicourse

ESEA Title III Project

1974

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SE019 614

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October 8, 1974

Nolan Estes
General Superintendent

This Minicourse is a result of hard work, dedication, and a comprehensive program of testing and improvement by members of the staff, college professors, teachers, and others.

The Minicourse contains classroom activities designed for use in the regular teaching program in the Dallas Independent School District. Through minicourse activities, students work independently with close teacher supervision and aid. This work is a fine example of the excellent efforts for which the Dallas Independent School District is known. May I commend all of those who had a part in designing, testing, and improving this Minicourse.

I commend it to your use.

Sincerely yours,

Nolan Estes

General Superintendent

NE:mag

CAREER ORIENTED PRE-TECHNICAL PHYSICS

TECHNICAL RESEARCH

MINICOURSE

RATIONALE (What this minicourse is about)

Scientific research has formed the basis for most of our consumer convenience items, our national security, our methods of producing enough food to keep our population well fed, and our handling of the multitude of problems that must be overcome to keep our great urban centers operating.

One might then feel that it is appropriate to investigate what goes into good scientific research. When a person gets an idea for a new device, seldom does the person go into a shop or laboratory and emerge a few hours later with a newly-invented device which will be on the market by day after tomorrow. Rather, it takes much experimentation and research to just get the item functional; then manufacturing and marketing research must be done.

Before one begins to do research on something, one must know what question is to be answered. If one cannot identify the question, one may well not know the answer when it is arrived at. A person must learn to ask good questions that adequately identify the problem to be solved before beginning to do research.

The purpose of this minicourse will be to familiarize you with the procedures used in scientific research by allowing you to do a complete piece of technical research of your own design. You are expected to keep a notebook during this minicourse. The notebook should contain all notes and an adequate record of your investigations. In addition, you will compile your results into a formal paper to be presented to the teacher (and perhaps to your classmates) orally. Your grade will be determined partially from the research paper and from your notebook.

In addition to RATIONALE, this minicourse contains the following sections:

1) TERMINAL BEHAVIORAL OBJECTIVES (Specific things you are supposed to learn from this minicourse)

2) ENABLING BEHAVIORAL OBJECTIVES (Learning "steps which will enable you to eventually reach the terminal behavioral objectives)

3) ACTIVITIES (Specific things to do to help you learn)

4) RESOURCE PACKAGES (Specific instructions for performing the learning Activities, such as procedures, references, laboratory materials, etc.)

5) EVALUATION (Tests to help you learn and to determine whether or not you satisfactorily reach the terminal behavioral objectives)

a) Self-test(s) with answers to help you learn more.
b) Final tests, to measure your overall achievement.

TERMINAL BEHAVIORAL OBJECTIVES

Upon completion of this minicourse, you will be able to:

1) formulate a good question.

2) write a research proposal.

3) perform a related literature search.

4) design an appropriate experiment that should serve to answer the question.

5) summarize the data and results of the experiment to answer the question.

6) present your ideas and the results of your research in good formal style that would be acceptable for publication in a learned journal.

ENABLING BEHAVIORAL OBJECTIVE #1	ACTIVITY 1-1	RESOURCE PACKAGE 1-1
Demonstrate the ability to ask a good question.	Complete Resource Package 1-1.	"Asking Questions"
ENABLING BEHAVIORAL OBJECTIVE #2	ACTIVITY 2-1	RESOURCE PACKAGE 2-1
Prepare a survey of the literature about your question.	Complete Resource Package 2-1.	"A Survey of the Literature"

ENABLING BEHAVIORAL OBJECTIVE #3 Design an experiment or procedure to incorporate what you have gained from the literature to help you answer your question.	ACTIVITY 3-1 Complete Resource Package 3-1. Perform the experiment.	RESOURCE PACKAGE 3-1 "Experimental Design"
ENABLING BEHAVIORAL OBJECTIVE #4 Demonstrate the ability to display, summarize, and interpret your data.	ACTIVITY 4-1 Complete Resource Package 4-1.	RESOURCE PACKAGE 4-1 "Collecting and Interpreting Data"
ENABLING BEHAVIORAL OBJECTIVE #5 Demonstrate the ability to make a formal presentation of research using good formal style.	ACTIVITY 5-1 Prepare a formal research paper using the form in Campbell's Form and Style in Thesis Writing, D. I. S. D. Bulletin #157--Manual of Standard Usage or some other accepted standard in this area. Read Resource Package 5-1.	RESOURCE PACKAGE 5-1 "Comments on Writing a Formal Research Paper"
ENABLING BEHAVIORAL OBJECTIVE #6 (Optional) Present the results of your research to a "committee of learned men of science" chosen by your teacher from your classmates.	ACTIVITY 6-1 This presentation will give you the opportunity to be held up to public questioning on the validity of your research.	

RESOURCE PACKAGE 1-1

ASKING QUESTIONS

If you are a typical high school student, you may react with the idea, "I don't have any questions" if told to ask some questions. This, however, is not the case at all. In the course of just living through a day you encounter many things that you wonder about; but because you have no facilities at hand to investigate the phenomena, you forget them and continue on your way.

Consider a child about the age of five to seven. If you will permit it, the child will keep a constant stream of questions coming at you because of his wonder about many things. You did this too but have perhaps forgotten about it. By being told to hush by your parents and teachers, or by other types of educational experiences, you have stopped consciously asking questions.

We want you to start asking questions again, because out of this you will come up with some ideas that will not only be good; but since they are yours, you will be interested in following them to their culmination and have fun doing it.

Most students have difficulty making their questions sufficiently specific when they begin this type of activity. If the question is a broad or general one, you probably will not be able to find an answer or solution in the time you have. It is very important that your question address itself to a sufficiently narrow topic that you can explore in depth and have some chance of answering it. This is known as "delimiting the study." As you do your work, you will come across many things that would

be nice to include or to explore; but you must discipline yourself to continue your original investigation with no deviation. After you complete your original investigation, you might well wish to pursue other questions that have arisen.

INSTRUCTIONS:

For the next twenty-four (24) hours, make yourself conscious of the fact that you want to remember all the things you wonder about. Be sure to have with you a pencil and pad of paper and to write each item down at the time you wonder about it. Omit nothing, because what you think at the time is not worthwhile may well be. There are some worthwhile aspects of technical physics that are worthy of investigation in almost everything you might consider, whether it is why a water pipe makes noise or how a hang glider sails.

After you get some questions written down, discuss them with some of your friends and your teacher. At this point, you and your teacher should agree on one of these for you to pursue through this mini-course.

RESOURCE PACKAGE 2-1

A SURVEY OF THE LITERATURE

This portion of a piece of research is probably the most important section to the researcher in the presentation. It makes little sense to repeat things that have already been done by others, and it is important to know as much as possible about work done in the area before you endeavor to design an experiment.

You should find in your school library at least these following references to aid you in your survey: (1) the Readers' Guide to Periodical Literature, (2) the Understanding the Atom Series of pamphlets (published by the Atomic Energy Commission), and (3) the magazines, Scientific American and Science. These will probably give you some worthwhile information.

After you exhaust these sources, plan to spend an evening or a Saturday in a public library or in some college or university library that welcomes high school students. (If you live in Dallas, with a student bus card you can ride the city bus downtown for fifteen cents. These are available in your principal's office.) In these libraries you should be able to find several abstracting guides, such as Chemical Abstracts, Physics Abstracts, Biological Abstracts, Nuclear Science Abstracts, and Physical Science Abstracts. These list all of the journal articles on a particular subject, tell you where to find them, and give you a short synopsis of the article to help you determine whether or not you should read it. You should find that you will likely enjoy the time you spend in this endeavor.

After you collect a number of related articles, you should write them up in the Related Literature section of your report. At best, this section probably will not read smoothly, because it is made up from the writings of many different authors. It should also be pointed out at this time that there is no place in a section of this kind for original material. The original material will come in later sections. All entries must be properly credited with footnotes.

RESOURCE PACKAGE 3-1

EXPERIMENTAL DESIGN

The specific points of your experimental design will have to be determined by the nature of the question asked. You may want to do some sort of laboratory experiment, some sort of mathematical treatment of data gathered or of data someone else has presented in the literature, or some sort of summarization of other results.

All that really can be said in general about the subject of experimental design is that it should:

1) be designed for one specific outcome directed toward answering your question,
2) contain an ordered set of steps to be followed,
3) identify the point where the data is to be taken (if appropriate)
4) identify the conditions under which the experimentation is to be performed.

Now, design an experiment to answer your question identified in Enabling Behavioral Objective #1.

RESOURCE PACKAGE 4-1

COLLECTING AND INTERPRETING DATA

From performing your experiment you should collect some data. You should have some orderly plan to handle that data and display it so that it is usable. As you are collecting your data, you should keep careful orderly records of that data and place it in appropriate tables or displays so that the reader can readily see the kind of information you obtained.

Next, you should have your treatment or method of interpretation of that data carefully explained so that the reader can readily follow you through your steps to get from your data to your results, interpretations, or conclusions.

Numerical data is most effectively presented in matrix or graphical form. Other types of data (ordinal) may be presented in narrative form, but endeavor to find a better way to display it. This is also the section where your feelings or opinions may be expressed because this is where the results of your work are presented.

RESOURCE PACKAGE 5-1

COMMENTS ON WRITING A FORMAL RESEARCH PAPER

The final assembly of your paper is extremely important if it is to be acceptable by one of the professional or trade journals. It is, therefore, a must that the form of the paper be correct and meet the requirements of such publications.

When one reads your paper, the work will be completed. Therefore, present or future tenses of verbs are generally excluded. All verbs are usually in the past tense. No first person pronouns (I or we) are conventionally included in the paper. Third person pronouns (he, she, it) are acceptable. An example of your statement of the problem might be, "The purpose of this research was to determine the effect of light on the growing of flowers." If the opportunity comes in your presentation to say, "I think," or "I feel," the correct way of expressing it would be, "Based on the data, one might conclude that," or something to this effect.

Although this has been stated previously, we should mention again that every statement and idea in your research paper should be properly footnoted if it is not original.

The following is a list of suggested chapter titles for a technical research paper. While some variation from these may be appropriate for the particular subject, your general outline should be close to this: